Salmonid

Enhancement Program

Fact Sheet Number 1

FISHWAYS: An Enhancement Tool

Fisheries and Environment Canada

Pêches et Environnement Canada

FISHWAYS: An Enhancement Tool

(adapted from an article by Dixon Makinnon)

Each year, from early spring to late fall, the streams that drain the Pacific coast of Canada are filled with salmon; the young migrating to the sea, the adults returning to spawn and die. Some of the spawners must travel hundreds of miles to their hereditary spawning grounds.

Time to complete the long upstream journey is limited. The salmons' biological time clock is set by heredity to bring them to full maturity as they approach their spawning area. It does not adjust to delay. Moreover, the fish stop feeding when they enter fresh water and draw on body fats and proteins for energy. They must reach the spawning grounds, deposit and fertilize their eggs, before the limits of their endurance are exceeded. Any changed condition in the waters that constitute their migration routes can be a threat to production of the next generation.

Rock slides are one of the hazards the fish might meet. A slide that only partly blocks a river can convert formerly negotiable rapids into a roaring torrent that drains the salmon of energy as they fight to maintain position in the current. Such a slide blocked most of the sockeye run in the Babine River in 1951. The fish that managed to surmount the obstacle were so weak and battered that few reached the spawning grounds, and of those few, between 30 and 40 percent of the females died unspawned. The famous Babine Lake sockeye run had been decimated.

Unusually high water can also cause turbulent, impassable stretches in rivers, with drastic effect on the salmon runs. Conditions of late snow-melt and sudden runoff one spring delayed the early Stuart Lake run of sockeye for just six days, and of the 30,000 to 35,000 spawners expected in the Stuart River, just over 2,000 actually arrived.

The most common natural obstructions encountered in the coastal streams of British Columbia are waterfalls and rapids. When they are impassable they may deny salmon access to potential spawning grounds; when they only partly obstruct the fishes' upstream progress they can inflict injuries and cause fateful delays. Sometimes passage can be opened with judicious use of explosives and rock-removal. More often a fishway is the only remedy: a concrete and steel structure to dissipate the violent energy in the water and make it possible for the fish to surmount the obstruction without stress.

There are three major types of fishway used in British Columbia. The weir type consists of a series of vertical partitions installed at intervals down the length of a specially constructed channel or flume. Water from upstream flows over the top of the successive partitions, each slightly lower than its predecessor, creating a series of step-like pools which the salmon can ascend with ease. Weir fishways are most effective where water levels remain fairly constant. Where water levels fluctuate, they require constant attention.

The vertical slot fishway also creates a series of pools and drops, but its flows are discharged from pool to pool through narrow slots extending the full height of the partitions. The vertical slot fishway is self-adjusting. It provides passage for the fish through a range of changing volumes or levels of water in the stream, without requiring the adjustment of stop-logs or baffles, as in the case of the weir. In view of the flash discharge pattern of most coastal streams and the relative isolation of many fishways, this is a great advantage.

The denil fishway, the third type used in British Columbia, is essentially a short section of flume with baffles affixed to the sidewalls and floor. The energy of water passing through the structure is dissipated in turbulence caused by the baffles, leaving a narrow zone of low velocity flow. The denil fishway is particularly suitable for use in situations where more expensive conventional fishways are not warranted. Denil fishways can be installed at much steeper gradients, and for a given height of obstruction they can be substantially shorter. This is reflected in cheaper construction costs.

Placement of the entrance to a fishway is of strategic importance. Fish are attracted to the area of greatest flow, which is usually right over a falls. If the fishway entrance can be positioned where fish want to congregate, their unsuccessful attempts at surmounting the obstacle will be reduced in number. Sometimes rock work, a training wall, or even a barrier dam, is needed to divert water and fish toward the fishway entrance.

Fishways have been used for about 300 years in Europe, and were employed in British Columbia in the 1920's and '30's. However these early structures were all of the weir type. It was not until the evolution of the vertical slot baffle that the fishway was firmly established as a tool for the restoration or enhancement of salmonid stocks.

The vertical slot fishway was first used at Hell's Gate in the Fraser River canyon. The water drained from 84,000 square miles of central British Columbia surges through Hell's Gate, a constricting granite gorge only 110 feet wide at its narrowest point. For thousands of years salmon successfully fought past the Gate, travelling to spawning grounds as far as 600 miles beyond. Indian tribes in the far Interior relied on the fish for winter food supply, and early fur traders came to depend on dried sockeye for winter provisioning of lonely outposts.

In the late decades of the last century the commercial catch of Fraser River sockeye in saltwater and on the lower reaches of the river increased, until it reached a record take of 31 million fish in 1913. That record was never to be repeated. A man-made catastrophe had occured the winter before when rock from construction of the Canadian Northern Railway was dumped into the river at Hell's Gate. The dumping was routine; rock had been dumped at other points along the Fraser canyon as well.

In July the first salmon of that record 1913 sockeye run appeared at Hell's Gate. Some fish managed to pass upstream in higher water but, as the summer wore on, alarmed observers reported that "incredible numbers" of salmon were congregated in all the eddies and creeks for ten miles below the man-made blockage. Although rock was blasted out that fall, the stocks that migrate higher up the Fraser during July, August, and early September were largely destroyed.

The problem at Hell's Gate was made worse the following winter when a tunnelled cliff collapsed and 100,000 cubic yards of rock tumbled into the river. Frantic efforts were made to restore the river channel, but although by March, 1915 some 60,000 cubic yards of rock had been removed, the river bed could never be restored to its natural condition.

In the decades that followed, the commercial catch of Fraser River salmon steadily declined. Investigation by the International Pacific Salmon Fisheries Commission showed that the block at Hell's Gate was a major cause. To rectify the situation the Commission built two major fishways, one on each bank, between 1944 and 1946.

The design of these fishways was entirely new. Inside the structures are a series of crosswalls, or baffles. A vertical slot the full height of each baffle allows the water to flow from each pool into the next lower pool. The flow is regulated in ten-inch steps from pool to pool, with a total drop of nine feet. The average water velocity in each pool is one and one-half feet per second, well below the velocity of up to 25 fps in the river.

As the salmon runs to areas above Hell's Gate began to increase, the success of the first two fishways became apparent. Subsequently four more were added, to improve fish passage over the full range of river levels -- from ten to 92 feet -- which occur in the Fraser during salmon migration.

The fishways at Hell's Gate, in conjunction with smaller fishways at Bridge River and Yale Rapids, have allowed a substantial restoration of both pink and sockeye runs in the Fraser, and triggered a program of fishway construction by the federal Department of Fisheries. Starting in 1951 with two fishways at Moricetown Falls on the Bulkley River, and continuing at a rate of about one fishway a year installations were completed at the following rivers: Sproat, Nimpkish, Stamp, Kadjusdis, Cowichan, Naden, Indian (three), Quatse, Koeye, Kakweikan, and Meziadin.

Almost all these fishways were built at partial obstructions where water levels at migration time had made passage difficult for salmon. At Meziadin in the Nass River system, for example, 70,000 sockeye died at the falls the year prior to construction of the fishway. Tagging studies afterward showed the runs going through with no difficulty. This fishway, built in 1967 at a cost of three quarters of a million dollars, increased the number of sockeye spawning effectively from an average of 81,000 before construction to 117,000 afterward. The first two years of returns more than offset the total cost of the fishway.

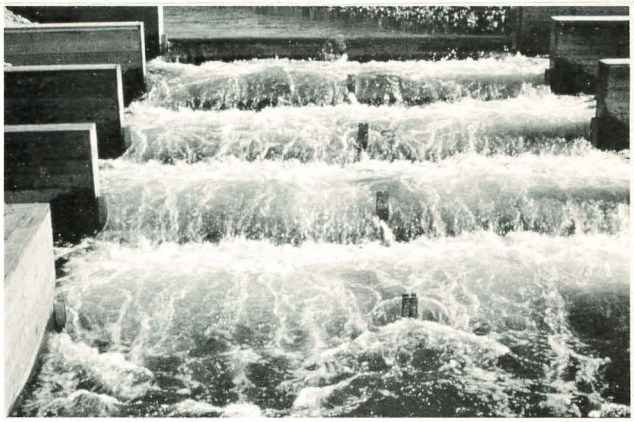
Although the decision to build a fishway can be influenced primarily by the economics of the project, other factors must also be evaluated. Are the reaches of the stream now accessible being utilized to capacity? How much additional spawning area would be made available? If sockeye salmon are being obstructed, are there lakes upstream? If there are, what are their capacities for rearing young sockeye? If coho and chinook are present, would adequate stream rearing areas be available? Is a fishway the best method of improving production, or would a hatchery or spawning channel offer a better alternative?

Each case must be studied to determine whether remedial measures are justified. Concrete fishways built in rock excavations can be extremely expensive to construct, especially if access must be provided to a remote site. Prefabricated denil fishways that can be airlifted in by helicopter have made it possible to place fishways at obstructions where access costs have hitherto been prohibitive. One such steep pass fishway, prefabricated of aluminum in Vancouver, was sent by boat and helicopter to a waterfall site on the Kakweikan River, near Knight Inlet. Pink salmon were never seen above the waterfall prior to installation of the fishway. Today runs of 100,000 to 230,000 pinks ascend the falls to spawn in previously unused stream bed. Now that it is known that the salmon will deploy in large numbers above the falls, it becomes economic to construct a permanent concrete fishway.

The use of the portable fishway as a testing device, and the entire trial concept, is important. Of 98 obstructions under investigation by the Fisheries & Marine Service as possible sites for fishways, 86 do not appear to be viable projects, and the actual benefits that would accrue from fishway construction at the other 12 could fall short of the estimated potential. Intensity of exploitation of the affected stock; intermingling of stocks; imperfections in the remedial measures taken; environmental pollution; reluctance of some stocks to travel beyond their traditional spawning area; these are some of the factors that can work against realization of the apparent full potential of a fishway (or other enhancement facility).

Of the 86 'problem' streams, 25 have obstructions at their mouths and are historically barren of salmon. The remainder are considered marginal because of remoteness, or because the existing runs of fish are not large enough to support rapid colonization of upstream areas. Given improved access for the fish and better management techniques, many of these streams could be better utilized in future.

The construction of fishways to circumvent obstructions blocking the passage of salmon and trout upstream is now an established technique; one that, in the right circumstances, can restore a depleted stock or add to a healthy one with minimal interference to the natural environment.



Pinkut Creek fishway